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Testing the Fisher-Foser Mark-I on-easel color analyzer

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SENIOR RESEARCH PROJECT

TESTING THE FISHER-FOSER MARK I ON-EASEL COLOR ANALYZER

By

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and

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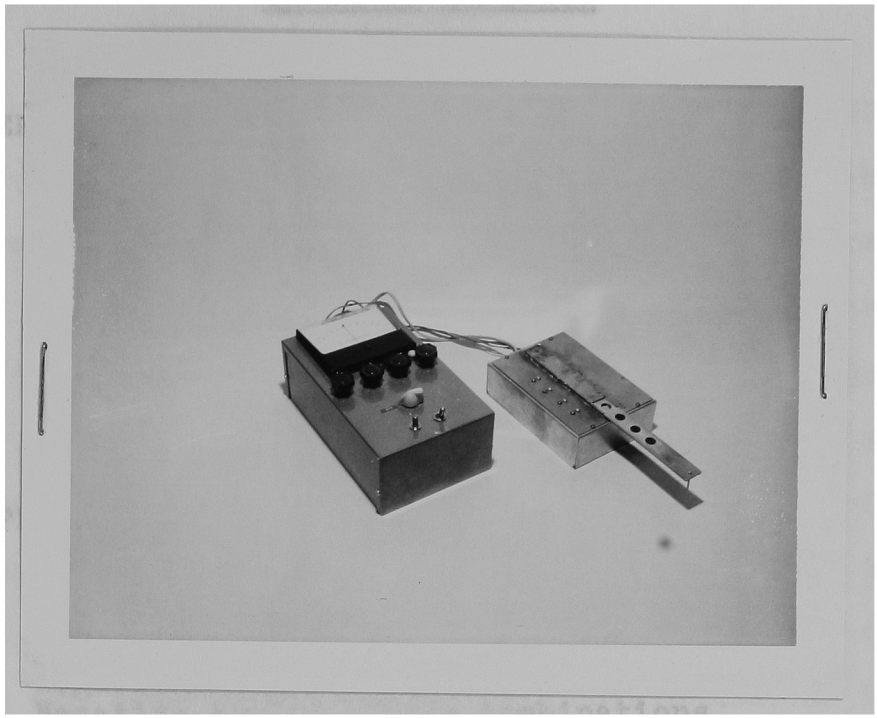

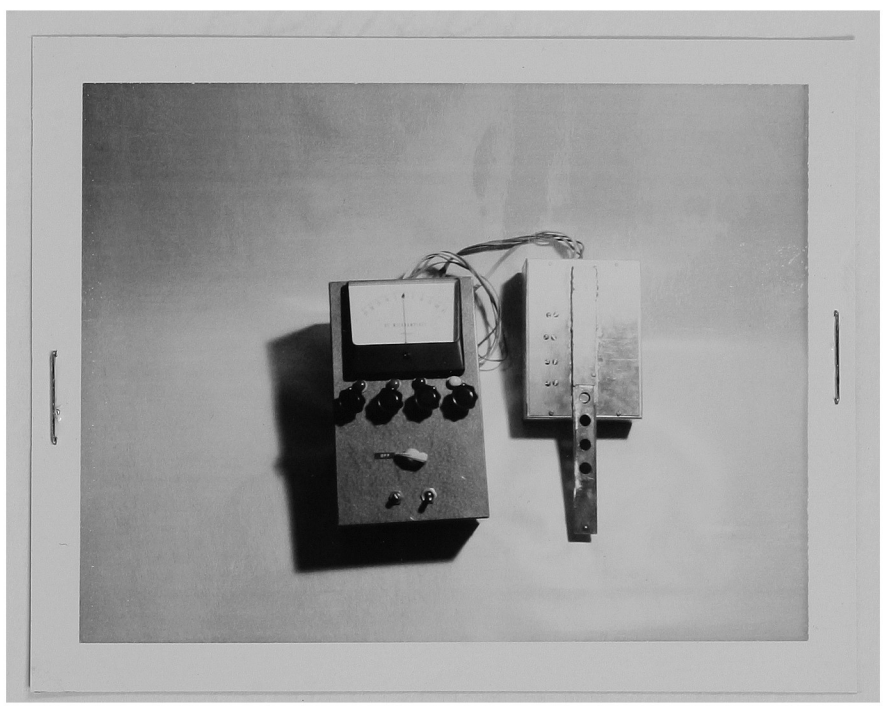

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ABSTRACT

It is proposed to test and statistically evaluate the performance of an on-easel color analyzer built by the authors. It is discovered during the testing program that the device is non-functional, and the testing program is re-directed toward finding the causes of the instrument mal-function. It is concluded that the particular characteristics of the cadmium sulfide cell employed, and the electronics of the device, introduce non-linearities which make readings non-repeatable. It is nevertheless felt that the concepts involved in the device, and in the testing program as originally envisioned, are sound, and that further development of the device would produce a useful color printing tool.

OBJECTIVE

To test an on-easel color analyzer of unique and original design and to compare it with one commercially available.

INTRODUCTION

Proper exposure and proper color-compensating filtration are two of the controls required to make a satisfactory color print. Color printing therefore requires some means of determining optimum exposure and filtration. Trial-and-error techniques are impractical both in terms of time and expense. There exists, therefore, a need for some means to predict exposure and filtration. Several commercial types of on-easel and off-easel devices have been marketed. They operate by comparing the tri-color densities of the production negative to those of a master negative.

It was our proposal that it was possible to build an on-easel color analyzer at a cost lower than that of present commercial units. This would enable the non-professional photographer to own a color analyzer for under $100.

The heart of the on-easel color analyzer which we built and tested was a cadmium sulfide cell, rather than a photo-electron tube. As in the Welch Densichron model 20 easel photometer, the commercially available unit which we used as a standard, a set of potentiometers was used to enter white-light and tri-color density values. A bridge circuit containing the potentiometers was used to compare the flow of current through the cell with the current flow through a fixed resistor. Two transistors were used to detect the current flow across the bridge and amplify it sufficiently to activate a micro-ammeter.

Our device was a null instrument and in operation was similar to the Densichron-20. A properly filtered master negative was used to set the potentiometers. The master negative and filters were then removed and the production negative was placed in the enlarger.

CC (color compensating) filters were introduced into the optical system of the enlarger until the meter returned to the zero scale marking, as it had when the master negative was in the system. The main difference between the two systems was in the nature of the probe. The cadmium sulfide cell had a greater signal output and therefore required less amplification. This resulted in greater design simplicity and reduced costs.

ORIGINAL TESTING PROCEDURE

When construction was completed, a few preliminary tests were conducted. The device was placed on the easel of a Chromega enlarger and the meter was zeroed for all four potentiometers. The filter wheels of the Chromega were adjusted and it was noted that a 5 CC change in filtration produced a noticeable shift of the meter pointer. On the basis of these brief practical tests it was decided that the meter was workable and a more exhaustive test procedure was developed.

The testing program was to be divided into two parts. First would have been a series of tests to determine the operating characteristics of the device. Second would have been a series of tests to determine its ability to predict filtrations for the satisfactory printing of unknown negatives. The ability of this device to predict corrective filtrations was to have been compared with the Densichron-20.

It was also to be determined if the sensitivity of the device changed at different levels of illumination. That is, was the minimal detectable filtration change a constant throughout a range of image brightnesses. If the sensitivity did change, illumination was to be adjusted during meter operation to the optimum level determined by this testing.

When this testing was completed it was planned that the unit would undergo further tests to determine both its ability to produce satisfactory prints and for its repeatability as compared with the Densichron-20.

The testing procedure was to be identical for both systems. First, a master negative containing an 18% reflectance gray card was to be prepared. The filtration necessary to produce a satisfactory print would be determined by trial-and-error. Since all measurements would be relative, and the exact filtration of the master negative would not be critical to the experiment, a satisfactory print was to be defined as one which was "pleasing" in color. A filter pack with the same tri-color densities as the gray patch area of the master negative was to be prepared using cyan, magenta, and yellow filters. This filter pack would be substituted for the master negative in the enlarger negative carrier, and would serve as a negative analog. The CC filters which had been used to balance the master negative would remain in the system. The instrument to be tested would be placed on the easel and the potentiometers would be adjusted to bring the meter to zero.

Test procedure would be to modify the negative analog by adding or subtracting density. For example, if 20M were subtracted from the negative analog, magenta filtration would be added to the printing filters until the meter returned to zero. Since the filters were both of the same dye composition and might in fact be the same filters, the unwanted absorptions and spectral absorption curve characteristics would be a constant in the system. Since the densities of the negative analog would be known, as well as the densities of the changes, the error could be calculated between the filtration recommeneded by the instrument and that filtration computed.

The test procedure was to be repeated by doing a new "ring-around" using another negative analog which was to be based upon a flesh tone in another master negative. This would demonstrate the ability of

the system to predict corrections in the two areas normally used as references in the printing of color negatives.

The system would then be used to determine the proper filtration for unknown negatives containing either a gray card or flesh-tone reference area. Prints will be made based on the prediction of the instrument.

Through replication, the repeatability of the two systems could be determined. The average values of each system, when compared with the calculated filtration change, would provide a measure of the accuracy of each system.

PRELIMINARY RESULTS

This had been our plan. A master negative containing a gray card area was prepared on 120 Kodacolor film. Through trial-and-error a satisfactory print was obtained. The filtration required was noted. Tri-color densities of the master negative gray patch were measured on the Macbeth TD 102 Densitometer and the densities were recorded. Cyan, magenta, and yellow Kodak CP filters were stacked until the pile had the same, or nearly the same, red, green and blue densities as the negative. The values of the filters in this pack were selected so that the total cyan, magenta, and yellow filtration could be varied, plus or minus 40 CC by substituting filters, without changing the number of filters in the pack. This eliminated inter-surface reflection problems by keeping the number of surfaces constant. Changes in the density of the negative analog was accomplished by substituting a filter of greater or lesser density for one already in the pack.

It had been planned to maintain the same number of surfaces in the printing filters too, but to maintain the same number of surfaces in a pack having a range of plus and minus 80 CC (allowing for over-shoots in predicting filtration) required a horrendous number of filters. It was decided to use instead the filters in the Chromega color head and calibrate them at a later date against the CP filters in the negative analog.

The treatment combinations of the experiment, as detailed in the Appendix, were arranged in random order. The Densichron-20 and our device were zeroed on the negative analog with 60 magenta and 60 yellow filtration in the Chromega system. The negative analog

was removed and its magenta density was increased 40 CC by removing 2 20M filters and replacing them with 2 40M filters. The instrument should have predicted a new Chromega filtration of approximately 20 magenta and 60 yellow. Approximately, because there would not be a 1 to 1 correlation of CP filters in the negative analog to the CC filters in the Chromega filter head. The instrument predicted 10M and 115Y instead of the calculated 20M and 60Y. The Densichron-20 was within 5 CC of the calculated values of both magenta and yellow. Our instrument was re-zeroed on the master negative analog and the experiment was repeated. Again our device predicted 10M and 115Y instead of 20M and 60Y. At this point it was decided that something was seriously wrong, and our testing was revised and redirected toward finding the cause of this serious malfunction.

MODIFIED TESTING PROCEDURE AND RESULTS

It was decided to reduce the 30 treatment combinations to 6, a "ring-around" at the 20 CC level. This, it was felt, would quickly give us an insight into the cause of the malfunction. This test series revealed that the instrument was not functioning at all as expected. It was not predicting the correct filtration and was not even replicating its own predictions. The data of this ring-around, and its replicate, can be found in the Appendix.

It was decided to plot the meter response against CC changes in the Chromega filter head. Yellow was chosen first. The graph showed an S curve, indicating that the probe saw first an increase, then a decrease, and then another increase in density as the filter wheel was steadily turned toward increasing density. Two other Chromega heads were tried, with the same results. A Densichron-20 and a Macbeth were also tried and neither of these instruments detected this S curve. This indicated that the difficulty was to be found within our instrument. Cyan changes also produced an S curve, although not as pronounced. Magenta exhibited no tendency toward this S curve non-linearity..

These plots of density changes versus meter response were repeated at different illumination levels and it was discovered that both the slope of the curve and the overall curve shape changed with the illumination level. Graphs of this phenomena are to be found in the Appendix.

CONCLUSIONS

The Fisher-Foser I gives every apperance that it should work. With the meter zeroed on a master negative, any change in printing filtration of 5 CC or more causes a noticeable deflection of the pointer in the meter. However, working with the device soon demonstrates that it is unstable and measurements are non-repeatable.

The non-linearity noted with changing illuminance level would be tolerable, since it is a null instrument, except for the fact that the S curve noted occurs near the meter zero point. In adjusting the filtration with an unknown negative in place, one finds the meter will "zero" at three different filtrations, over a 30 CC range.

Second, even allowing for the S curve problem, the meter is non-repeatable. If the meter ie zeroed and the filtration is change, returning the filtration to its original state will not necessarily re-zero the meter. If the filtration is changed until the meter does re-zero, there is no guarentee that the filtration predicted this time will be predicted next time.

It is the conclusion of the experimenters that the Fisher-Foser I, while conceptually sound, is plagued by problems which render it un-useable. The cadmium sulfide cell seems to lie at the heart of the problem due to its time-lag characteristics. Much of the trouble with the yellow filters may be due to the low sensitivity the cell exhibits to blue light. The effects of light and dark adaptation may cause the photo-resistive material to exhibit different resistances to the

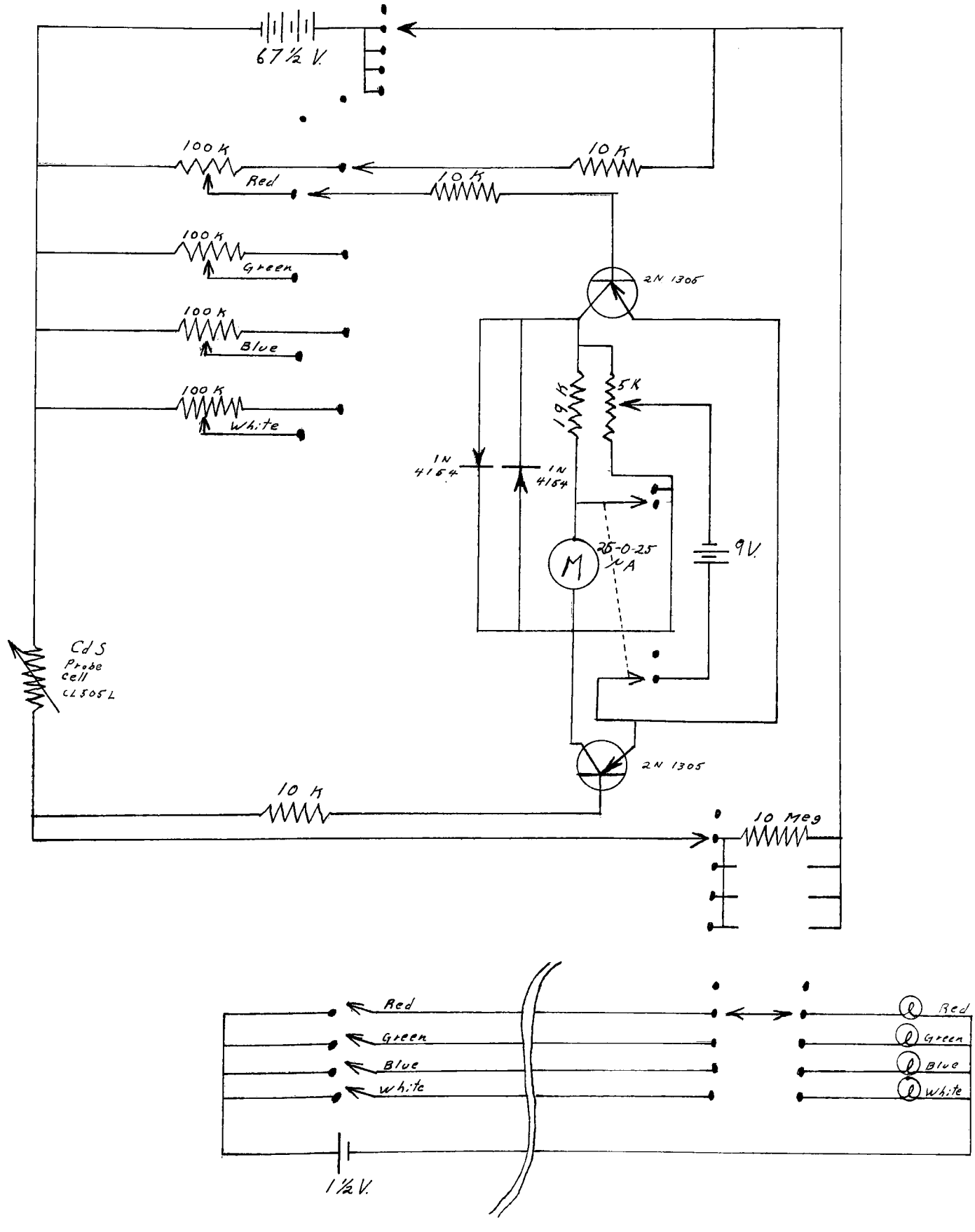
same light level, at different times. The characteristic time-lag in the cell response, plus the extremely slow, long duration drift exhibited at low light levels, further complicate the matter. Using the green probe filter, magenta filtration determination seems quite workable because the cell has high green sensitivity. Red is moderately successful, but blue sensitivity makes yellow filtration determinations impossible. Because of the overlapping CC filter absorptions, an incorrect value for the yellow filtration throws the magenta filtration off, making the magenta filtration data in the experimental data look worse than it actually is. At this stage it looks as if blue sensitivity must somehow be increased.

As the purpose of this project was primarily to test an instrument, rebuilding has not been attempted. However it is evident that considerable circuit sophistication will be required to compensate for the problems which have plagued this first model. A photo-resistive material with greater blue sensitivity and increased stability is needed before it will be possible to construct a workable instrument.

APPENDIX

FISHER-FOSER I SCHEMATIC

AND CIRCUIT DESCRIPTION


67½ V.
100 K
Red
10 K
10 K
100 K
Green
100 K
Blue
100 K
White
2N 1305
19 K
5 K
IN 4154
IN 4154
25-0-25 μA
9V.
Cd S Probe Cell CL505L
2N 1305
10 K
10 Meg
Red
Green
Blue
White
1½ V.
Red
Green
Blue
White

FF I CIRCUIT DESCRIPTION

Basically the FF I is a bridge circuit. The amount of light falling on the photo-resistive cell changes its resistance. The bridge circuit compares this resistance to that of a 10 megohm fixed resistor. A 100 K potentiometer is used to balance the two sides of the bridge. A 10 K fixed resistor is in series with the potentiometer to limit the current flowing through the cell.

A nine volt battery is used to power an amplifier consisting of two transistors. A 5 K potentiometer is used to balance the bias to obtain equal gain on both transistors. Two 10 K fixed resistors are used in series to protect the transistors from excessive voltage.

The bridge imput to the transistors is amplified so that sufficient current will flow through the meter to cause an observable deflection. In the meter circuit two diodes and a 19 K resistor are employed as a "clipper circuit" to protect the meter from excessive current, should the bridge become unbalanced, or excessive light strike the probe.

A multi-deck rotary switch is used to connect the amplifier circuit to the red, green, blue, and white potentiometers used to enter the bridge balancing factors. This switch also activates the pilot light system.

PARTS LIST

FISHER-FOSER I PARTS LIST

QUANTITY	DESCRIPTION	UNIT COST	TOTAL COST
	PROBE		
1	Cadmium sulfide photoconductive cell	$1.50	$1.50
1	1.5 volt battery	.20	.20
1	battery holder	.40	.40
4	micro-switches	1.45	5.80
1	4' 8conductor cable	.50	.50
--	brass	3.30	3.30
1	metal box	1.40	1.40
3	filters (92, 98, 99)	1.50	4.50
	METER		
1	DC micro-ammeter	23.00	23.00
5	potentiometers	2.00	10.00
2	2nl305 transistors	.30	.60
2	transistor sockets	.20	.40
2	diodes	.42	.84
5	resistors	.15	.75
1	rotary switch	4.75	4.75
4	bulbs	.30	1.20
4	sockets	1.00	4.00
1	9 volt battery	1.40	1.40
1	67½ volt battery	3.15	3.15
2	battery connectors	.70	1.40
3	terminal strips	.15	.45
1	switch	1.25	1.25
5	knobs	.15	.75
1	metal box	2.60	2.60

OPERATING INSTRUCTIONS FOR THE FISHER-FOSER MARK I ON-EASEL COLOR ANALYZER

adapted from the Densichron manual

INTIAL ADJUSTMENTS

1. MECHANICAL ZERO-- Before turning on the power, check the mechanical zero meter adjustment. Turn the screw in the lower front center of the meter cover until the meter pointer is centered over the zero scale mark. Scotch tape may be used over this adjustment screw to prevent accidental turning.

2. WARMUP-- Place instrument on location for use, but without power. Turn selector switch to calibrate. Turn power switch on. Adjust amplifier balance until the meter pointer is centered over the zero scale mark. This adjustment will have to be repeated several times during the first five minutes of warmup. After this time the amplifier is quite stable, but should be checked from time to time during operation. To do this, turn the selector switch to calibrate and adjust the amplifier balance if the meter pointer is no longer centered.

The instrument is now ready for color balance and exposure calibration.

APPLICATION

A. THE BASIC IDEA IN COLOR BALANCE AND EXPOSURE

The basic use of the FF I (Fisher-Foser Mark I On-easel color analyzer) in enlarger color balancing is to match the relative proportions of red, green and blue light of a production negative to that of a master color negative. This is done by reading through a key area of the master negative which has been color balanced to produce an excellent print. This might be a flesh tone or a gray card area. Using the FF I each production negative is individually measured and adjusted with CC filters (generally CC magenta and CC yellow) so each one has the same proportion of red, green and blue enlarging light passing through the same type viewing area used as a reference for the master negative. At the desired enlargement the lens opening is then adjusted so that the production negative timing area has the same white light FF I exposure time reading on the meter as that used to expose the master negative. This exposure time and color balance should give as good, or close to as good, a color print from the production negative as from the master negative. Variations are due to such things as personal preference, imperfections of filter curves, processing variations, storage conditions, etc.

B. THE MASTER COLOR NEGATIVE

Select or make a good master or practical type color negative. This should be a high quality negative made under optimum conditions. It will be used as a reference in the printing of production negatives to the results desired. For a practical flesh tone master have one or more of such as as a head and shoulders shot. The background should be average type. It should not include large abnormal areas of strong color whose reflections or lens flare might upset color balance.

For gray card work, the standard 8 X 10 photographic gray card of 18% reflection or equivalent is excellent. It may be included in a scene with flesh tones or in a good typical "average scene". Be sure that strongly colored reflections from walls or other bright strong colored areas do not change the apparent neutrality of the gray card. This master should be one of normal exposure, made by light of normal color quality (or with proper conversion filter) and with known good color development. Any master may also include color patches.

A good color print is now made by trial and error. This step must be done at least once for good calibration. It is also best done with the equipment and at about the exposure time that will be used in regular production color printing. Good records should be kept of the CC filters, exposure time, lens opening, magnification, paper emulsion number, etc., that are used. The best operating conditions are set up for a good color print from the master negative and balanced into the FF I. These conditions can then be duplicated by using the FF I to set up the same balance on the production negatives.

C. CALIBRATING THE FF I FOR EXPOSURE

It will be assumed that the correct exposure for the master negative is fifteen seconds at F/8 with 2X enlargement, and the enlarger is so set. The FF I is to be set to read this exposure. Place the FF I probe on the easel with the aperture on a strong diffuse flesh tone highlight. The forehead above the nose is good if no reflex highlight or shadows are present. The brighter cheek is also good under similar conditions for men. On women, powder may change flesh tones. (Don't measure a greasy, shiny or reflex highlight nor a back lighted highlight.) Turn the five position rotary selector switch to white. Move the probe slide until the white light under the meter lights, indicating that the clear opening is centered over the probe cell. Turn the white potentiometer, directly under the white light, until the meter pointer is centered over the zero scale mark. This exposure sensitivity setting is left constant until practical work or tests indicate the need for some refinement.

When there is no flesh tone, timing is made from a near highlight of about the same density as a strong diffuse flesh highlight. This is a density appreciably below a strong white. It is apt to be a more critical point for exposure reading than a full strong white. The strong white is already well into the toe of the sensitivity curve. Differences in strong whites thus do not always vary as much as the practical exposure from one negative to another. Generally do not try to est the exposure timing by a gray card, as the light on such a card is not always proportionate to the general lighting of a picture because of its placement angle.

When using a master negative in preliminary work and setting the FF I to read exposure time, use the CC filter pack even if you have not yet found the best CC combination. Trim the setting to just right when you have the best combination.

D. CALIBRATING THE FF I FOR TRIPLE ZERO COLOR BALANCING

The triple zero method is theoretically the most exact method in that the color balance analysis is made with all CC filters included in the system. No filter changes are made between the final readings and the time of making the exposure.

It will be assumed that the correct CC filtration for the master negative is a CC75M and CC80Y. Have this filtration in the enlarger and also the master negative. Place the FF I probe on the easel to read the same type flesh tone on the master that is to be dupolcated from production negatives. Open the lens wide. Make the following adjustments.

a) Turn the five position rotary selector switch to blue. Move the probe slide until the blue light under the meter lights, indicating that the blue filter is centered over the cell aperture. Turn the lens down two stops* and adjust the blue potentiometer, directly under the blue light, until the meter pointer is centered over the zero scale mark. This adjustment is made on the assumption that the blue setting for the selector swithc practically needs a more sensitive setting for the photometer than other colors. This is due to the heavy blue light absorption of the yellow dye mask layer, the low blue in tungsten light, the inherent high density of sharp cutting blue filters, and the low blue sensitivity of cadmium sulfide photo-resistive materials. This form of adjustment to the blue light reading keeps the FF I at its highest effective sensitivity.

b) Turn the five position rotary selector switch to green. Move the probe slide until the green light under the meter lights,

* See "Operating Techniques" for discussion of optimum light level.

indicating that the green filter is centered over the cell aperture. Turn the green potentiometer, directly under the green light, until the meter pointer is centered over the zero scale mark.

c) Turn the selector switch to red. Move the probe slide until the red light lights, and adjust the red potentiometer directly below until the meter pointer is centered over the zero scale mark. This meter reading is the color balance referencing point for production.

The FF I is now balanced for flesh tones. Put a production negative to be printed in the enlarger. Place the probe to read a flesh tone which is to print like that of the master negative flesh tone area. As a beginning, remove all CC filters. Then use the following steps to adjust color balance and exposure for each production negative:

a) Set the selector switch to red. Move the probe slide until the red light under the meter lights. Open or close the lens until the meter reads zero. This referencing position generally does not need any CC filtration.

b) Turn the selector switch to the green position. Move the probe slide until the green light lights. Insert magenta filters until the meter pointer is centered over zero.

c) Turn the selector switch to the blue position. Move the probe slide until the blue light under the meter lights. Insert yellow filters until the meter pointer is centered over zero.

d) Again set the selector switch to red and move the probe slide until the red bulb under the meter lights. Again adjust the lens opening slightly so that the meter pointer is centered over zero.

e) Turn to green and move the slide until the green bulb lights. Adjust the magenta filtration as necessary to center the meter pointer over zero.

f) Now return to the blue position and check the yellow filtration.

g) Continue checking red, green, and blue and adjusting filters until the meter pointer is centered over zero for all three.

h) Turn the five position rotary selector switch to white. Close down the enlarger lens until the meter pointer is centered over zero.

i) Put a piece of unexposed color paper on the easel and make the exposure.

j) Process and examine the print for color quality and exposure level. It should be close to or exactly the quality needed. If not quite correct, examine with CC filters, or estimate the color and time correction needed and repeat the printing.

OPERATING TECHNIQUES

Because of the sensitivity of the instrument, body capacity may have a small effect on the readings. For this reason be consistant in the way you handle the meter. It is suggested that the aim point be that condition in which the meter pointer is directly over the zero scale marking without the operator touching any part of the instrument.

Cadmium sulphide cells have an inherent characteristic: a slight "time lag" in changes from one illumination level to another. This time delay occurs whether the FF I is turned off or on, and is a function of the light on the cell, not the current running through it. The action of the time delay will depend upon the level of illumination at which you are working. At high levels of illumination it may be a matter of only a few seconds for a two-fold (1 stop) increase or decrease in light level, while at very low light levels a two-fold change may cause a time lag of three minutes or more. However, by briefly flashing the cell with a small flashlight, (which can also be employed to read the meter face in the darkroom,) or by briefly blocking off all light, the delay in one direction or the other can be substantially reduced.

If one defines sensitivity as the magnitude of the change in response divided by the magnitude of the change in imput, the FF I will be found to INCREASE in sensitivity as the illumination level DECREASES. However, there is a price to be paid. At high levels

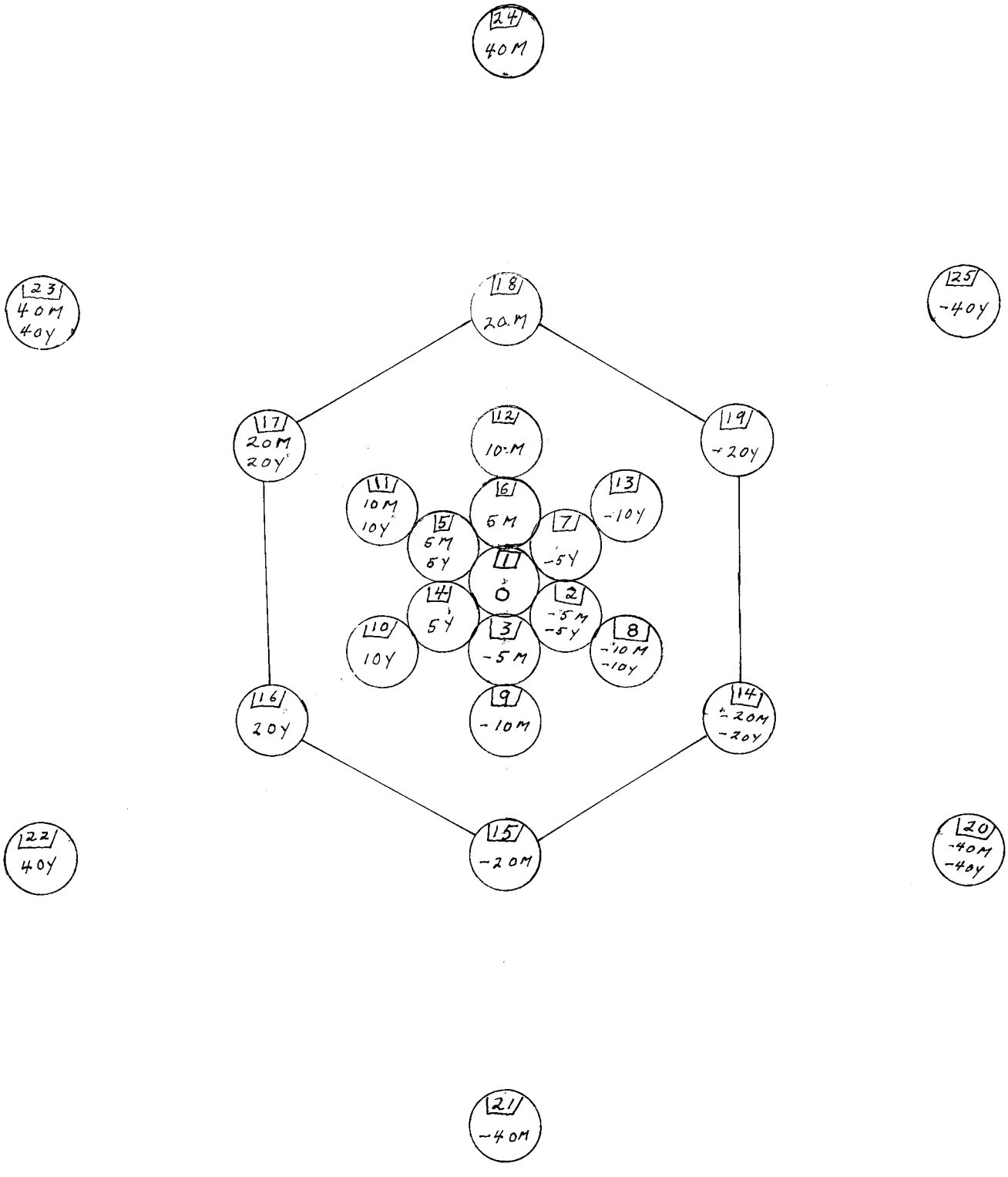
of illumination, "time lag" is at a minimum, but a fairly large change in light level may go undetected because the meter movement is so small. At low levels small changes in light level are easily detected because the meter movement is great. However, at these low levels the time lag becomes so long that meter use becomes impractical. Compounding the time lag problem is a certain amount of meter drift which also becomes apparent at these low light levels.

It therefore follows that there is an optimum light level to employ when adjusting the color balance filtration of a negative. At this optimum level, meter pointer movement is sufficient to enable the operator to easily detect a small CC change, but without excessive time lag or drift problems. This level can be determined by the operator through a little preliminary experimentation with his normal enlarging set-up, and different light levels. In practice, using a Chromega enlarger and a $2\frac{1}{4}$ square Kodacolor negative, at"normal" negative densities and "normal" degrees of enlargement, this point has been found by the authors to be about F/8.

NEGATIVE ANALOG VARIATIONS

EXPERIMENTAL TREATMENT COMBINATIONS

The chart on the following page illustrates the original treatment combinations planned, except for the 80 CC ring which is not included. The 20 CC ring, which is connected by straight lines, indicates those variations from the central negative analog which were actually tested.


24
40M
23
40M
40Y
18
20M
25
-40Y
17
20M
20Y
12
10M
19
+20Y
11
10M
10Y
6
5M
13
-10Y
5
5M
5Y
7
-5Y
1
0
4
5Y
2
-5M
-5Y
10
10Y
3
-5M
8
-10M
-10Y
9
-10M
16
20Y
14
+20M
-20Y
22
40Y
15
-20M
20
-40M
-40Y
21
-40M

NEGATIVE ANALOG FILTER COMBINATIONS

	CYAN CC			MAGENTA CC				YELLOW CC					
Negative analog CP filters	40	20	5	20	20	10	10	40	40	20	10	10	5
Plus 20 magenta					20	20							
Plus 20 yellow											20	20	
Plus 20 magenta and 20 yellow					20	20					20	20	
Minus 20 magenta				10	5	5							
Minus 20 yellow										10	5	5	
Minus 20 magenta and 20 yellow				10	5	5				10	5	5	

This chart shows the filter values that are substituted in the negative analog to obtain the modifications listed in the first column. The negative analog contains 13 filters at all times so that the number of inter-surface reflections remains a constant. They are always stacked in the left to right order shown at the top of the page, with the 40 C closest to the light source and the 5 Y closest to the lens.

20 CC RING-AROUND DATA

20 CC RING-AROUND

NEGATIVE ANALOG		FISHER-FOSER I		DENSICHRON 20		COMPUTED "CORRECT" VALUE	
MAG.	YEE.	MAG.	YEL.	MAG.	YEL.	MAG.	YEL.
0	0	84	35	58	65	60	60
0	0	60	36	60	55	60	60
20	0	35	85	38	73	40	60
20	0	32	60	37	65	40	60
0	20	55	55	60	48	60	40
0	20	64	80	60	40	60	40
20	20	37	60	38	52	40	40
20	20	40	105	37	42	40	40
-20	0	110	31	75	60	80	60
-20	0	76	35	77	52	80	60
0	-20	94	27	60	83	60	80
0	-20	65	78	60	75	60	80
-20	-20	108	29	80	78	80	80
-20	-20	82	80	76	70	80	80

Explaination of this data and the testing procedure are to be found on the following page.

20 CC RINGAROUND

A negative analog, consisting of a stack of cyan, magenta, and yellow filters, was prepared so that it had approximately the same density as a gray patch area of a Kodacolor negative. The printing filtration of the master negative was 60M and 60Y. The FF I and the Densichron were zeroed with these printing filters in place, along with the negative analog. The first two columns show the changes in the magenta and/or yellow densities of the negative analog. The different combinations were prepared in random order. First the FF I was used to predict the proper printing filtration, and its prediction for magenta and yellow densities are to be found in the third and fourth columns. Then the Densichron was used to predict the correct printing filtration, and its prediction for magenta and yellow densities are to be found in the fifth and sixth columns. The last two columns are computed by adding to the printing filters what has been subtracted from the negative analog and vice versa so that the total density remains a constant. Since both instruments are null instruments this is the value the should predict approximately, allowing for differences in CC and Cp filters and their placement in the optical path.

Several days later the experiment was replicated and the data from day two is the second line in each of the seven horizontal sets representing different negative analog combinations.

ILLUMINATION DEPENDENCE

ILLUMINATION DEPENDENCE

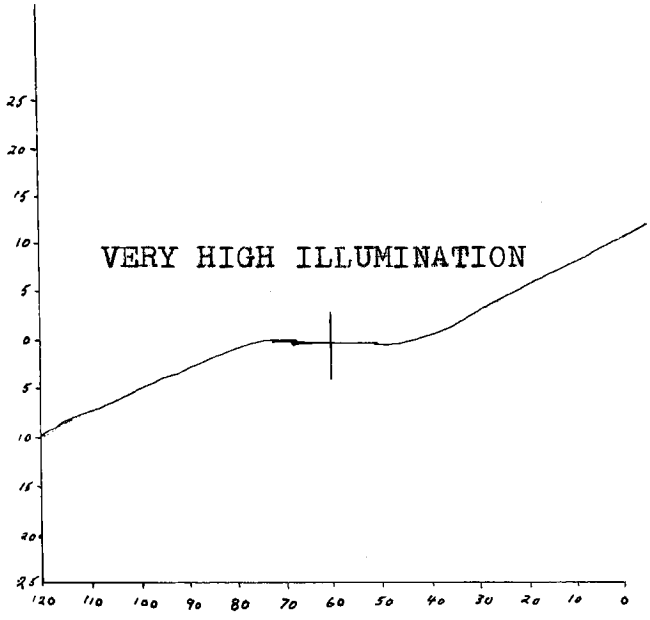
It is suggested that as the illumination is decreased the response of the Fisher-Foser I to changes in filtration exhibits the following characteristics:

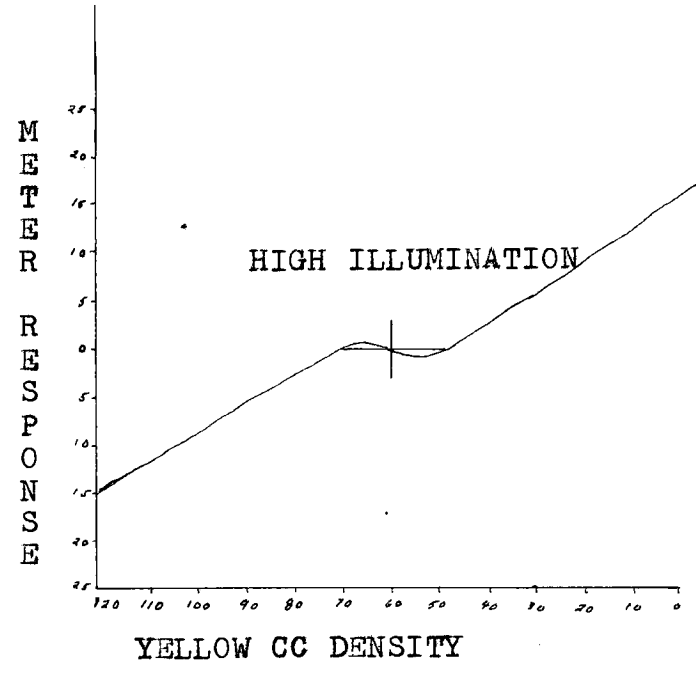
1. The range of the meter movement is increased
2. The average slope increases
3. The response becomes increasingly non-linear

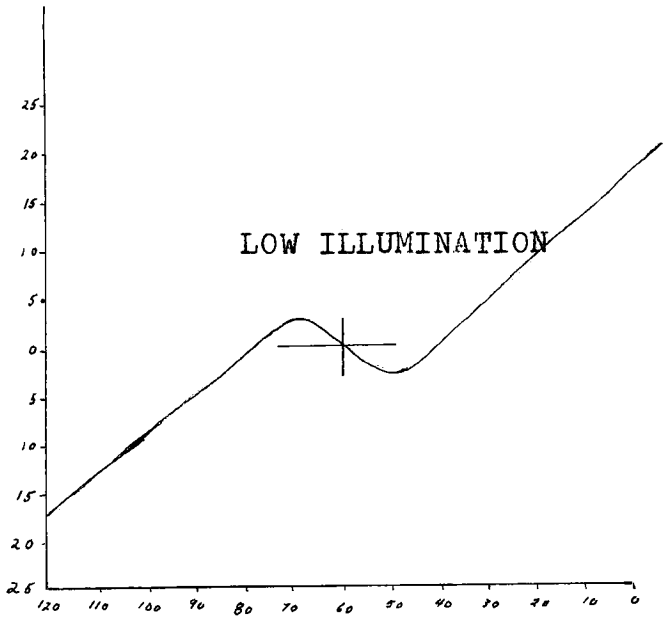
At low levels of illumination, particularly when using the blue filter to detect changes in yellow filtration, there is a range of approximately 30 CC in which the curve crosses the zero line three times. The charts on the next page sketch this phenomenon, with the cross-lines representing the aim point, zero response at 60 CC Yellow filtration. It can easily be seen that false zero readings 15 CC to each side, make the FF I an un-workable null instrument at low illumination levels.

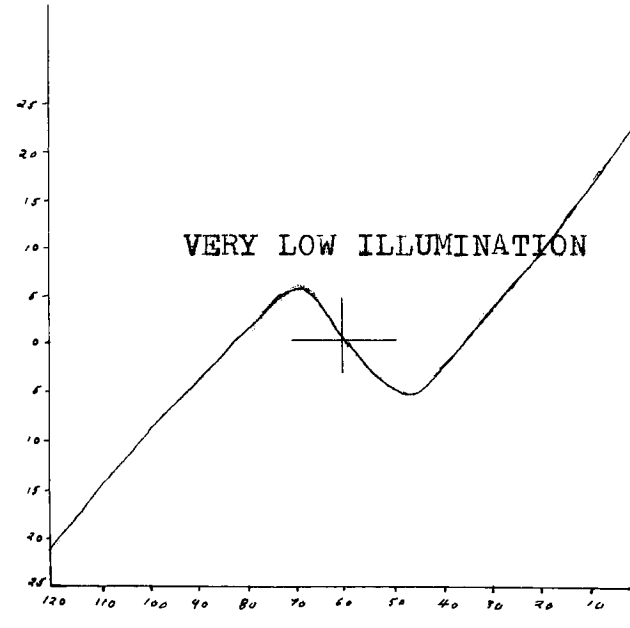
It is further suggested that this non-linearity is a function of the cell characteristics, rather than the electronics of the system. Evidence for this is to be found in the fact that this phenomena is pronounced in the blue, but almost unnoticeable in the green. The electronics of both systems are identical, the only difference being in the affected area of the cell spectral response.

DIFFERENCES IN RESPONSE CURVE AT DIFFERENT ILLUMINATION LEVELS

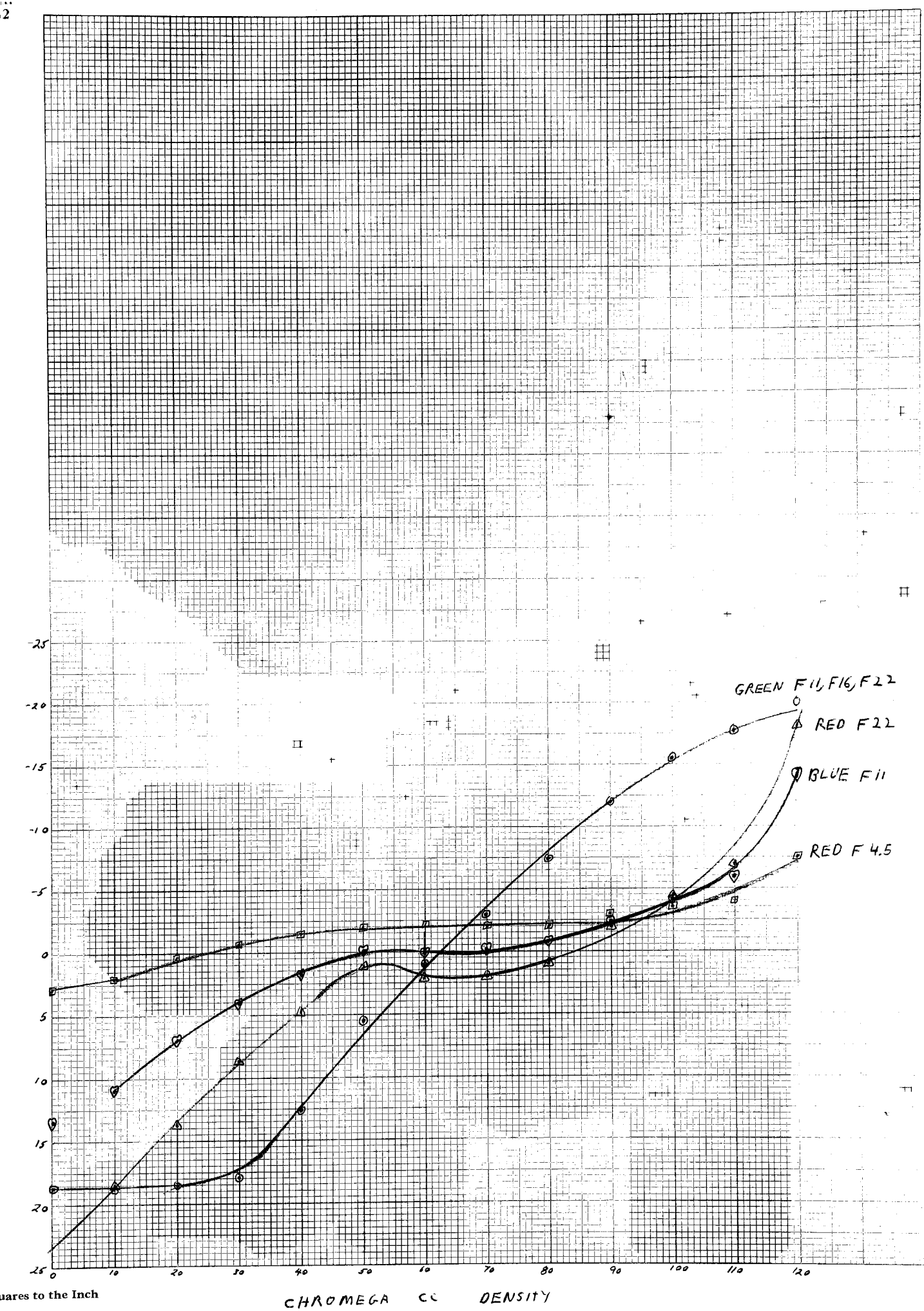




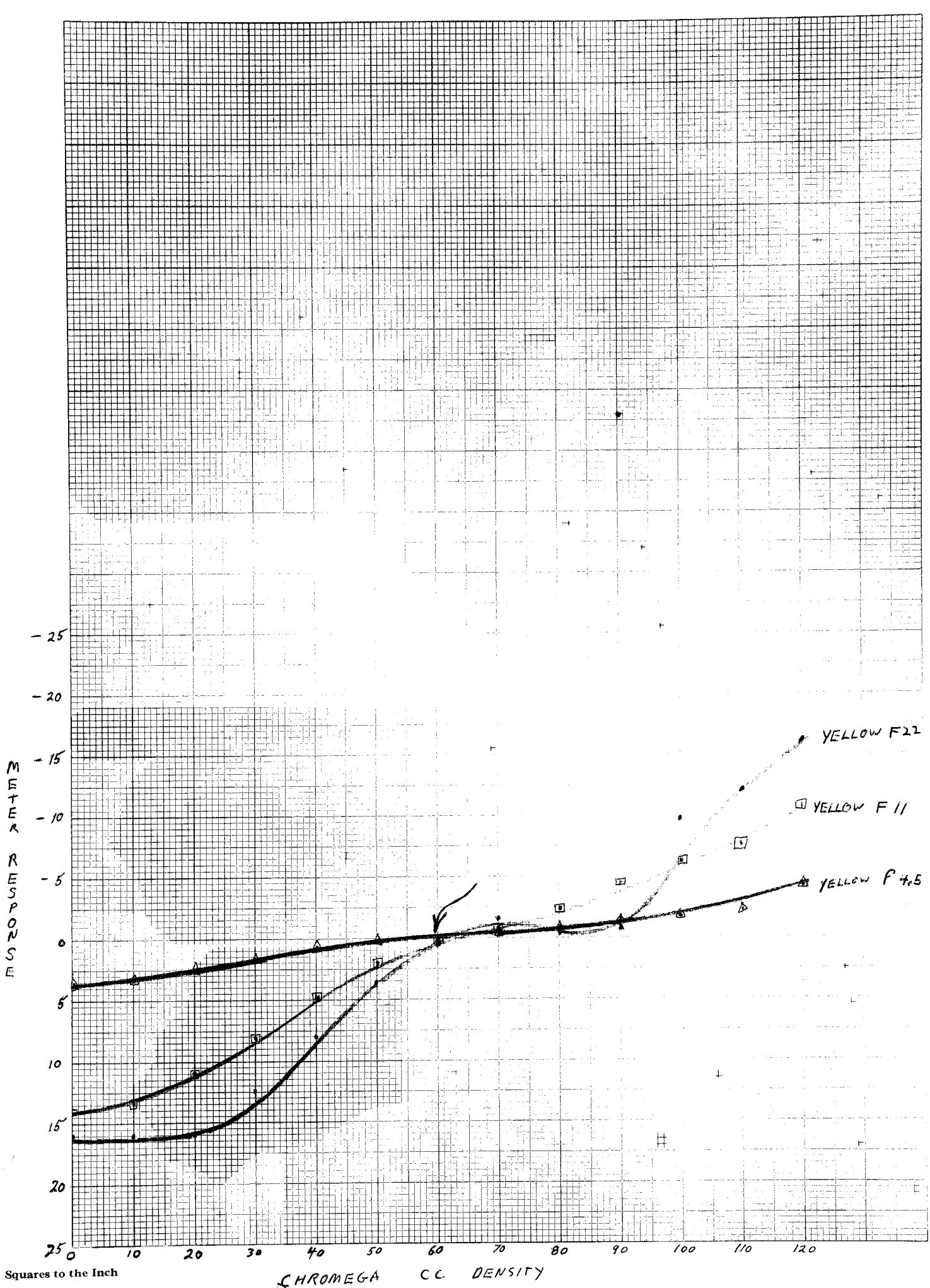




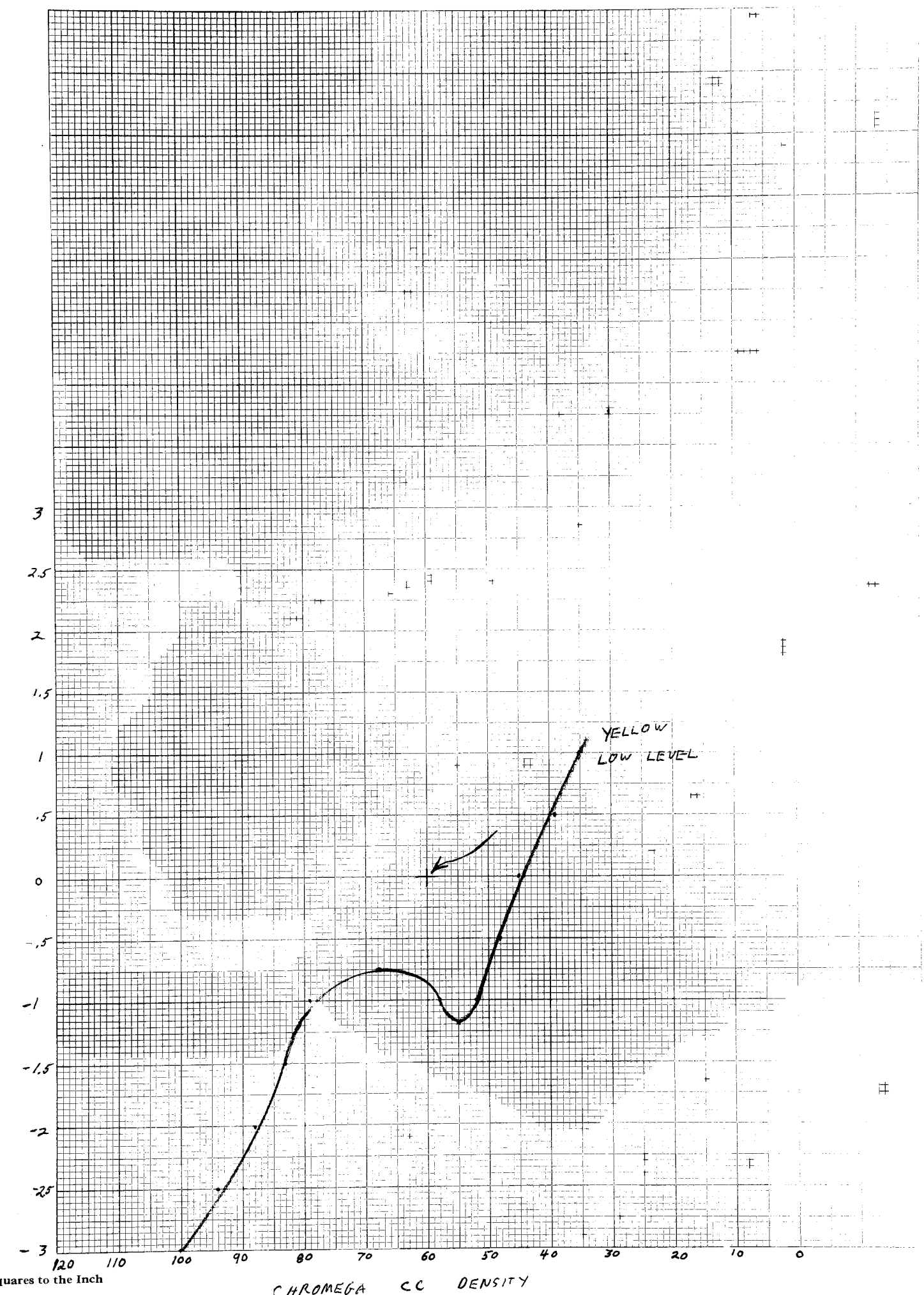
The following graphs show the actual experimental data which was obtained as we investigated the meter response curve characteristics. From these graphs it can be seen how the curve varies for different spectral regions and different light levels. The vertical scale shows the deflection of the meter needle from zero and the horizontal scale shows the number of CC's of filtration dialed into the Chromega system. In all cases the FF I has first been zeroed on OC, 60M and 60Y as this was our printing aim point. Then the filter wheels were turned and the meter deflection was recorded.



uares to the Inch



Squares to the Inch



quares to the Inch

ORIGINAL PROJECT PROPOSAL

SENIOR RESEARCH PROJECT

THE FISHER-FOSER 25 MILLI-K COLOR ANALYZER

C. Donald Fisher and Richard C. Foser

OBJECTIVE

To test an on-easel color analyzer of unique and original design and to compare it with one commercially available.

PROCEDURE

In the printing of color photographs there exists a need for some means of determining optimum exposure and predicting the necessary filtration. Trial-and-error techniques are impractical both in terms of time and of expense. Several commercial types of on-easel and off-easel devices have been marketed. They operate by comparing the tri-color densities of the unknown negative with those of a master negative.

It is proposed that it is possible to build an on-easel color analyzer at a cost lower than that of present commercial units. This would enable the non-professional photographer photographer to own a color analyzer for around $25.

The heart of the on-easel color analyzer which we propose to build and test is a cadmium sulfide cell, rather than a photo-multiplier tube. As in the Densichron, a group of potentiometers is used to enter white-light and tri-color density values. A bridge circuit containing the potentiometers is used to compare the flow of current through the cell and through a fixed resistor.

Its operation is similar to the Densichron in that a master negative is used to set the potentiometer values. Filters are then placed under the unknown negative until the meter returns to the zero position it occupied when the master negative was in the system. The main

difference between the two systems lies in the nature of the probe. The cadmium sulfide cell has a greater signal output and therefore requires less amplification. This results in greater design simplicity and reduced costs.

TESTING

The testing program will be divided into two parts. First will be a series of tests to determine the operating characteristics of the device. Second will be a series of tests to determine its ability to predict filtrations for the satisfactory printing of unknown negatives. The ability of this device to predict corrective filtrations will be compared with that of the Densichron 20.

The potentiometers will be centered and a properly filtered negative will be placed in the enlarger. When tri-color measurements are made with the probe, filters will be placed over the probe to zero the meter. This will insure that the current flow the cell will be of the same order of magnitude for all three color measurements. This will minimize temperature changes in the cell.

By inserting and removing an infra-red filter, it will be determined if the probe is IR sensitive. If it is, an IR filter will be inserted in the optical system.

Finally it will be determined if the sensitivity of the device changes at different levels of illumination. That is, is the minimal detectable filtration change constant throughout a range of image brightnesses. If the sensitivity does change, illumination will be adjusted during meter operation to the optimum level determined by this testing.

When this testing is completed the unit will undergo further

tests to determine both its ability to produce satisfactory prints and for its repeatability as compared with the Densichron 20.

The testing procedure will be identical for both systems. First, a master negative containing an 18% reflectance gray card will be prepared. The filtration necessary to produce a satisfactory print will be determined by trial-and-error. Since all measurements are relative and the exact filtration of the master negative is not critical to the experiment, a satisfactory print is to be defined as one which is "pleasing" in color. The system to be tested will be placed under the enlarger and zeroed with the master negative and filters (necessary for a satisfactory print as previously determined) in place. Then, with the instrument zeroed, the negative and filters will be removed.

The instrument readings will be brought back to zero by placing cyan, magenta, and yellow filters in the negative carrier. Thus a filter pack, having the same tri-color densities as a properly filtered negative gray patch will be created. This will result in the creation of a negative analog with approximately the same transmission characteristics as a properly filtered negative gray card area.

Test procedure will be to modify the negative analog by adding or subtracting filters. For example, if 20M is subtracted from the negative analog, magenta filtration will be added until the meter returns to zero. Since the filters are both of the same dye composition and may in fact be the same filter, the unwanted absorptions and spectral absorption curve characteristics are not factors. Since the densities of the negative ahalog will be known as well as the densities of the changes, the error can be calculated between the filtration recommended by the instrument and that computed.

The test procedure will be repeated by doing a new

"ring-around" using another negative analog based on a flesh-tone master negative as the starting point. This will demonstrate the ability of the system to predict corrections in the two areas normally used as references in the printing of color negatives.

The system will then be used to determine the proper filtration for unknown negatives containing either a gray card or flesh tone reference area. Prints will be made based on the prediction of the instrument.

Through replication the repeatability of the two systems can be determined. The average values of each system when compared with the calculated filtration change will provide a measure of the accuracy of each system.

We propose not only to construct a unique color analyzer, but also to employ a method of color prediction testing, independent of the processing variables normally encountered by testing techniques involving actual negatives and measurements taken from color prints. It is our belief that our testing method will yeild more meaningful estimates of system repeatibility and system error.

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